U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1339

RED CLOVER CULTURE

RED CLOVER is the most important leguminous forage and soil-improving crop in the northeastern quarter of the United States.

It will grow on any well-drained fairly rich soil that has plenty of lime in it. Without lime or on hard run-down land in which the organic matter has been exhausted by bad cropping, it will not thrive.

The most common method of seeding is on winter grain, but it also is often seeded with spring grain. Late summer seeding is successful in much of the southern and eastern part of the clover area.

Red clover is most often seeded with timothy, though sometimes with other grasses. With timothy the hay of the first crop year is mostly clover; the second year the timothy is most heavy, and after that the clover largely disappears.

Clover is most used in rotations with a cultivated crop and a small-grain crop in three, four, and five year rotations.

Root borers and other insects as well as fungous diseases make it undesirable to keep a field of pure clover more than one crop year.

The use of high-quality seed of American production is strongly advised. Imported seed is often unfit for use in the United States, and seeding it is always risky.

The secret of haymaking consists in the rapid removal of the moisture from the cut plants without killing the leaves prematurely.

Seed is usually taken from the second crop. The yield is always more or less uncertain, and over much of the clover area it is cut down more by the clover-flower midge and the clover-seed chalcis fly than by any other factor. The injury caused by these insects can be minimized by cutting the first crop a little earlier than is usually done.

RED-CLOVER CULTURE.[1]

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With Notes on the Insect Enemies of Red Clover, by W. R. WALTON, formerly *Charge of Cereal and Forage Insect Investigations, Bureau of Entomology.*

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INTRODUCTION.

RED CLOVER[2] is one of the most important and most widely known of all cultivated legumes. Either alone or in mixture with other plants, chiefly timothy, it is the most used forage and soil-improving crop throughout northern and central North America and Europe, and its culture as a rotation crop extends far beyond these boundaries. For centuries it has been regarded as the corner stone of a permanent system of agriculture in the Old World, while in this country for nearly 200 years it has been a leading factor in conserving productivity of the soil. The distinguished part which red clover has played in maintaining a profitable world agriculture can scarcely be overstated.

Red clover is adapted primarily to growing in rotations with other crops, and it has therefore been largely used in those regions where a variety of crops is grown. By far the most common method of utilization is to grow it in a three or four year rotation, including a cultivated crop and a small-grain crop, the first crop of clover being cut for hay and the aftermath being turned under or allowed to go to seed. This is an exceedingly economical and convenient procedure, and, together with the high feeding and fertilizing value of the plant, largely accounts for its dominant position among farm crops.

The most serious problem at present confronting the American farmer in many of the clover sections is the increasing difficulty of successfully maintaining stands of clover.

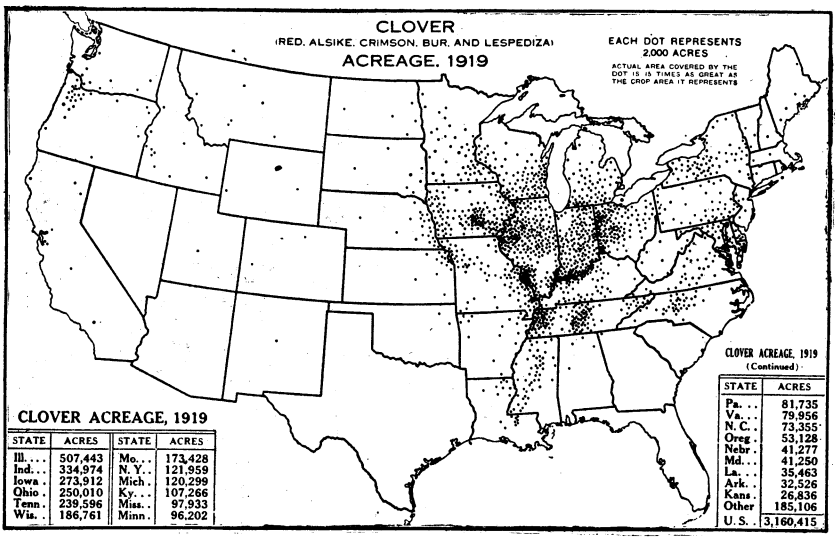
[1] This bulletin is a revisioon of and supersedes Farmers' Bulletin 455, "Red Clover, by J. M. Westgate and F. H. Hillman.

[2] When the term "red clover" is used in this bulletin, the common red, medium red, or June red clover (*Trifolium pratense*) is to be understood. For other varieties, see p. 23.

With continuous cropping and the consequent reduction of the humus and plant food in the soil the difficulty of growing red clover is greatly increased. This condition must be met and solved, since the loss of clover or its equivalent from the rotation leads rapidly to a run-down farm and unprofitable crop yields.

HISTORY AND PRESENT DISTRIBUTION OF RED CLOVER.

Red clover is native to the greater part of Europe and portions of Asia. The exact date of its introduction into America is not known, but in a work on agricultural plants written in 1747 by Jared Eliot observations concerning its adaptability to conditions in the New England States are noted. Since its introduction into this country



CLOVER ACREAGE, 1919

STATE	ACRES	STATE	ACRES
Ill.	507,443	Mo.	173,428
Ind.	334,974	N. Y.	121,959
Iowa	273,912	Mich.	120,299
Ohio	250,010	Ky.	107,266
Tenn.	239,596	Miss.	97,933
Wis.	186,761	Minn.	96,202

CLOVER ACREAGE, 1919 (Continued)

STATE	ACRES
Pa.	81,735
Va.	79,956
N. C.	73,355
Oreg.	53,128
Nebr.	41,277
Md.	41,250
La.	35,463
Ark.	32,526
Kans.	26,836
Other	185,106
U. S.	3,160,415

FIG. 1.—Outline map showing the acreage of clover grown alone (for timothy and clover mixed, see fig. 10). "Clover" may mean red, mammoth, or alsike clover in the Northern and Central States; crimson clover, a very different plant, in the Coastal Plain of Delaware, Maryland, and Virginia; bur clover in parts of the South; and it was specifically stated in the census schedule to include lespedeza.

it has spread greatly and is now grown to a considerable extent in nearly all the sections of the United States where there is sufficient rainfall. In the irrigated sections of the arid portions of the West red clover is largely replaced by alfalfa, but even in the irrigated sections in mountain valleys red clover is an important forage crop.

The accompanying map (fig. 1) shows the distribution of all clovers in the United States according to the census of 1920. Each dot represents 2,000 acres in the region where the dot is located.

DESCRIPTION OF THE RED-CLOVER PLANT.

The accompanying illustrations (figs. 2 and 3) indicate the general appearance of the red-clover plant. The plant is herbaceous and is composed of numerous leafy stems arising from a thick crown.

Red clover usually lives only two years and for this reason is especially adapted to short rotations. The flowers are borne in compact clusters or heads at the tips of the branches. There may be a hundred or more flowers to a single head. The flowers are rose-pink, somewhat similar in shape to pea flowers but much more elongated and smaller, being half an inch in length and one-sixteenth of an inch in width. The pods bear little resemblance to those of most other legume-bearing plants; they are small, short, and break open transversely instead of longitudinally as do pea and bean pods. (Fig. 4.) The kidney-shaped seeds are one-twelfth of an inch long and vary in color from yellow to deep violet. The stems comprise about three-fifths of the total weight of the plant above ground and in the American strain are usually somewhat hairy. Each leaf is composed of a slender stalk bearing three oblong leaflets, usually with a pale spot in the center of each. The roots are much branched, but usually deep feeding and are ordinarily well supplied with nitrogen-gathering tubercles. (See fig. 3.)

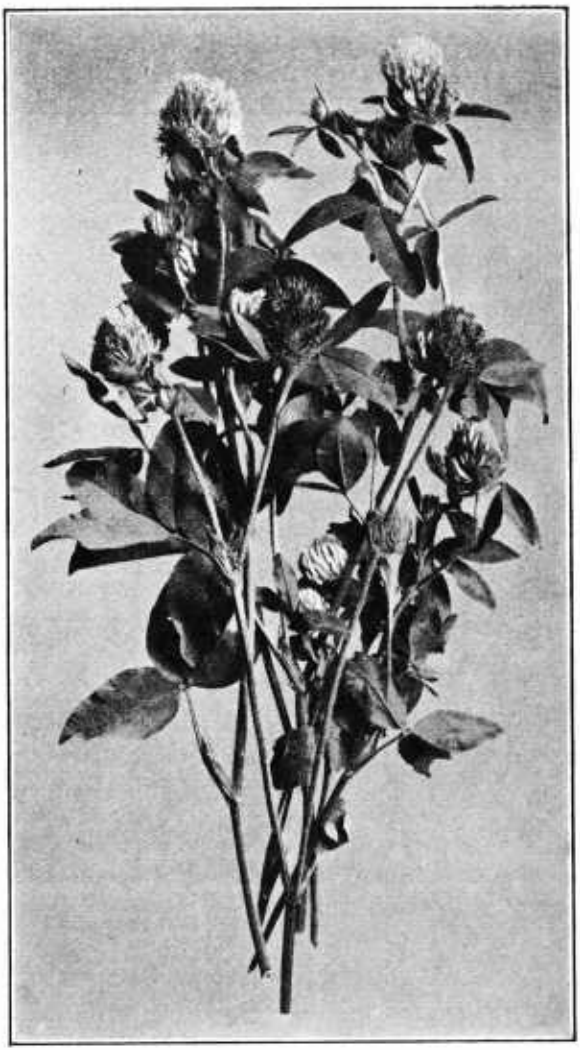


FIG. 2.—Stems of red clover in different stages of bloom.

WHERE RED CLOVER THRIVES.

Besides being the staple leguminous forage crop in the northeastern quarter of the United States, red clover is also grown in Idaho, Washington, Oregon, and in many of the valleys of the Mountain States. In the South it is locally grown, usually as a

winter crop, though there are places with rich moist soil where it does well the year around. In North Dakota red clover is being replaced by sweet clover, while in irrigated sections of the West alfalfa is preferred except in some mountain valleys where the growing season is too short for three crops of alfalfa, and especially where a leguminous crop is desired in connection with the customary grain crop. In some irrigated sections where the conditions are especially favorable for seed production it is grown primarily for seed.

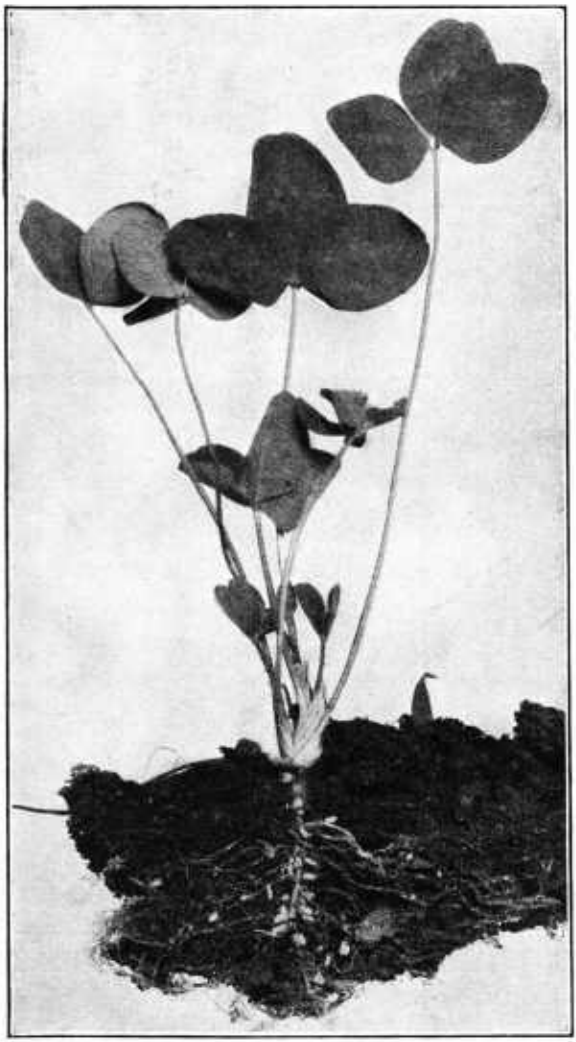


FIG. 3.—Young red-clover plant, showing tubercles on roots.

Red clover makes its best growth on rich, well-drained soil containing an abundant quantity of lime and reasonably free from weeds, but it is not so exacting as alfalfa in these respects. To low, poorly drained soils it is not so well adapted as alsike clover. Alsike will also succeed on the so-called clover-sick lands upon which for one reason or another red clover can no longer be successfully grown by the ordinary methods.

REQUIREMENTS FOR OBTAINING A STAND OF RED CLOVER.

CHOICE OF SEED.

The effort for a profitable stand of red clover has been well begun when the seed has been carefully selected. Three points must be considered in selecting clover seed: Purity, germination, and source of seed.

PURITY.

Good red-clover seed is plump, bright, and varies in color from yellow to deep violet. Some brown seeds are nearly always present,

but in a good sample they should not be numerous, since brown seeds are often dead. The impurities consist of dirt, sticks, broken seed, and seeds of other crop plants or of weeds. In all but the last case the farmer merely pays clover-seed prices for useless stuff, but when weed seeds are present he not only pays for them in the first place, but he may be put to considerable additional expense for a term of years. This is especially true if the weed seeds are those of buckhorn, wild carrot, Canada thistle, or dock. If a farmer uses his own seed or buys from a neighbor, he should reclean the seed as carefully as possible before seeding; if he buys from a dealer he should first have the seed examined by his State seed-testing laboratory if there is any doubt as to its quality. A simple magnifier, American made, such as is shown in Figure 5, is a useful thing and can be bought for about 75 cents. With it anyone can readily pick out the weed seeds in a sample of clover. Some of these weed seeds are shown in Figure 6. Good red-clover seed should be at least 95 to 98 per cent pure and should contain few weed seeds. Owing to the Federal seed-importation law and the various State laws, the deliberate adulteration of clover seed is now relatively rare.

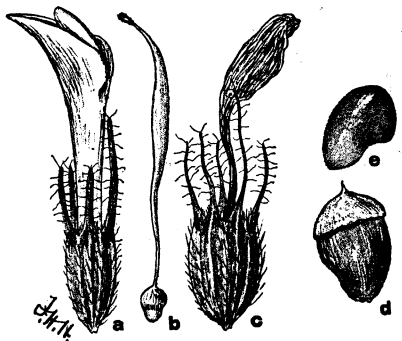


FIG. 4.—Stages in the development of red-clover seed: *a* and *c*, Flower in prime and ripe; *b* and *d*, immature and mature seed vessel; *e*, mature seed.

GERMINATION.

A bright fresh-looking lot of red-clover seed will usually germinate pretty well, but it is so easy to test the germination in advance that there is little excuse for sowing poor seed. If 100 or 200 average seeds are counted out and laid on a plate between pieces of moist cloth or blotting paper, as shown in Figure 7, and the plate set away in a room where the temperature is 65° to 80° F., the seeds will begin to sprout in three or four days, and in a week the value of the seed so far as germination is concerned can be definitely determined. The germination of clover seed, even when the sample is good, will depend somewhat on the number of hard seeds present. A sample of good seed should test something like 90 per cent, with at least several of the remaining seeds hard at the close of the 10-day test period. It is thought that one-third of the hard seeds will grow promptly when seeded.

FIG. 5.—Simple magnifier for examining seeds.

SOURCE OF SEED.

During the past 15 years considerable quantities of red-clover seed have been brought to the United States from foreign countries. Some of this seed was grown in southern Europe and was unfit for

use in this country. In the Ohio River valley and in the Great Lakes region and westward the plants from such seed are not winter hardy, and in the southern part of the clover belt they are more subject to disease than American plants. Not all imported red-clover seed can be condemned as wholly unfit for use in this country, but it can be confidently stated that American-grown seed will usually give better results than imported seed. An increase in the production in the United States of red-clover seed is highly desirable, since many of the failures experienced during recent years have been due to the use of imported seed, and not enough American seed is produced to supply the demand. When buying from dealers, farmers should insist on knowing the source of the seed and should use American seed whenever possible.

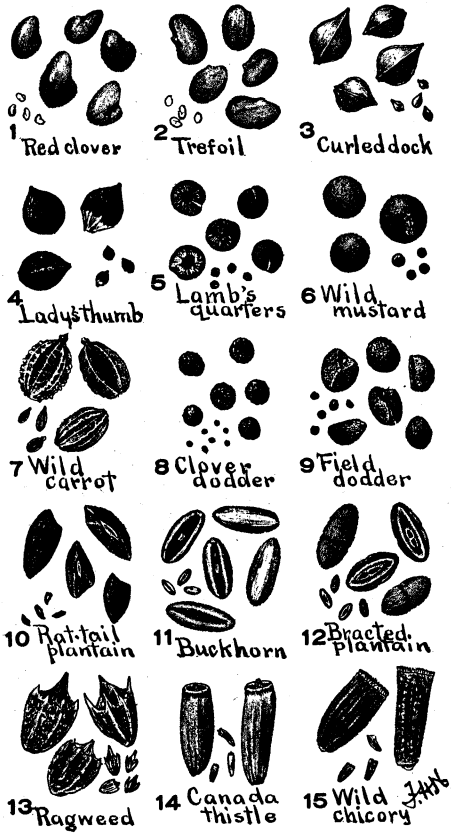


FIG. 6.—Seeds of red clover and common impurities.

SOILS AND FERTILIZERS FOR RED CLOVER.

Red clover is not a crop for extremely poor soils. On such soils more robust crops must be grown and turned under before a start can be had with clover. As a general rule throughout the clover belt any well-limed soil that will grow corn will grow clover. A deep, well-drained soil is desirable, as on a poorly drained soil red clover will not thrive; better sow alsike clover on such soils. Lack of nitrogen in the soil will not matter, since the clover will get nitrogen from the air.[4] Clover must have lime, phosphorus, and potash, however, and if the soil is poor in any of these it must be supplied before red clover can be expected to do well. The soil must also contain a reasonable proportion of organic matter. The limestone areas of the country are usually well suited to red clover, though even in these areas there are localities where the soil has become deficient in lime.

[3] For further discussions of clover seed, seed testing, and weed seeds, see Farmers' Bulletin No. 676, Hard Clover Seed and Its Treatment in Hulling; Farmers' Bulletin No. 428, Testing Farm Seeds in the Home and in the Rural School; and Farmers' Bulletin No. 1161, Dodder.

[4] For a fuller consideration of this subject and of green manuring, see Farmers' Bulletin 1250, Green Manuring.

When lime is needed, burnt lime, hydrated lime, or finely ground limestone can be used. Roughly, their relative effectiveness is about as 100, 75, and 50, and if this relation is borne in mind, the cost when laid down on the farm will indicate which form is best to buy.

Many soils in the clover belt are poor in phosphorus, and this can readily be supplied by the use of 200 or 300 pounds of 16 per cent acid phosphate per acre. Potash is more rarely lacking, but there are soils, especially in the East, where this element must be added, and on such soils 50 to 100 pounds of muriate of potash per acre will prove very helpful. When the grain with which clover is seeded is fertilized the clover will usually make a good growth on the same fertilizer. Manure is very valuable for clover, both when used on the corn preceding the clover and later as a top-dressing. (Fig. 8.) There is nothing better than good stable manure. In the Pacific Northwest sulphur and gypsum have proved useful, and 75 or 100 years ago gypsum or land plaster was used a great deal in the East. It has now been replaced by lime and phosphates.

The questions of lime and fertilizers are largely local ones. The soils in the clover belt vary widely, and the various fields on the same farm may need different treatments. The most suitable treatment for each farm or each field is best determined by a test, and this can be made without a great deal of trouble. The accompanying

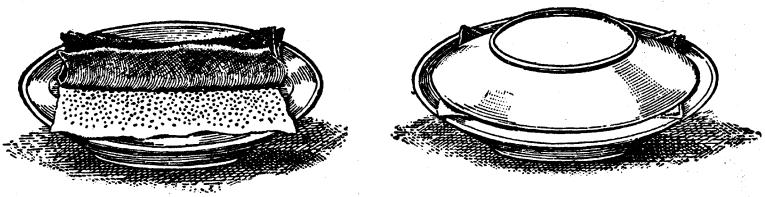


FIG. 7.—Homemade seed tester or germinator.

diagram, Figure 9, illustrates how this can be done. In this outline no potash has been suggested. Potash plats can be inserted if desired, but over most of the clover area scarcity of phosphate is much more common than scarcity of potash, and by following the outline presented here the farmer is likely to find which fertilizer it is best to use. This has been so arranged that all the lime and all the manure can be applied to one continuous area. The phosphate alone must be applied to separate areas, and phosphate is the easiest to apply. A ton of ground limestone and 250 to 300 pounds of 16 per cent acid phosphate per acre is suggested unless the land is known to be very poor in lime, when 2 tons of ground limestone may be applied.

This outline (fig. 9) illustrates the principle of definite experimentation and can be varied to suit the kind of information wanted. One or more check plats to which nothing is added and which receive only the same treatment as the main field must always be left for definite comparisons.

SEED BED, SEEDING, AND NURSE CROP.

Clover seed is small and must have a fine seed bed, but while fine on top the bed must be firm. A loose seed bed is fatal to young clover; it dries out too fast. When clover is to be seeded on freshly

plowed land the field should be worked several times with soil-packers unless a heavy rain should intervene and pack the soil. On corn ground a good disking, perhaps followed by one harrowing, will usually put the seed bed in good shape.

Clover is most frequently seeded on winter wheat or rye or with spring grain. Of all these nurse crops, better called companion crops, oats is the most harmful, since its heavy growth makes a shade too dense for the young clover. When seeded on wheat the seed bed is usually in fair condition, and the clover seed may be sown on the ground when it is still freezing and thawing, as these processes will help to work the seeds into the ground. One successful practice is to sow half the seed in February. If there is a good stand no more seeding is necessary; if not, the remainder of the seed is put on in April. When seeding is delayed until the surface of the ground dries it is a good practice to harrow before and after seeding. The harrow if set to work about an inch deep will not hurt the wheat.

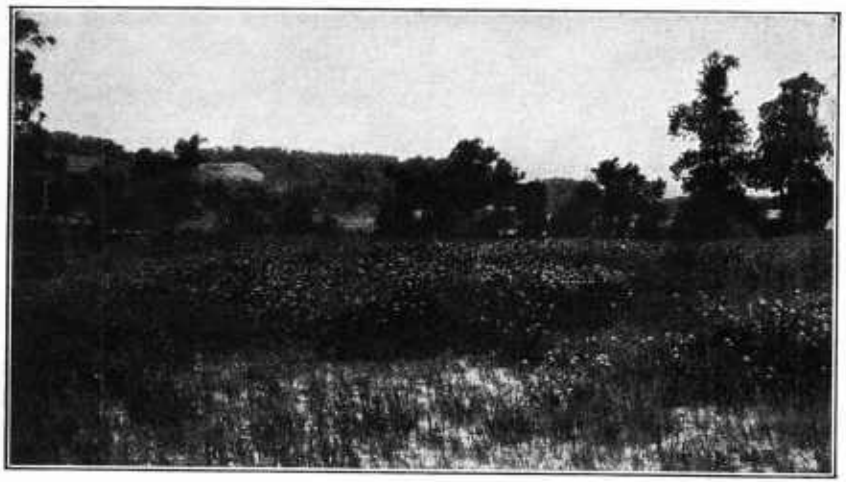


FIG. 8.—Red-clover field, showing the effect of top-dressing with manure. The area in the foreground received no manure; the area immediately behind received a light application, resulting in a very vigorous stand of clover.

Or the seed may be put in with a drill. This latter is the better practice, since less seed is needed and it can be put in at a fairly uniform depth. It is well to seed the clover crosswise of the wheat rows, which are best run north and south, as this enables the young clover to get the maximum light. Among seeders a wheelbarrow seeder or a seeding attachment to a 1-horse weeder are good tools. Among drills the special clover and alfalfa drill will give better satisfaction than a grain drill having a grass-seed attachment, especially when the clover is seeded alone, as on winter wheat. The clover-seed drill puts the seed in rows 4 inches apart and covers it to a more nearly right and uniform depth than can be done with a grain drill. If the clover seed is sown broadcast, 10 to 15 pounds per acre are used, but if drilled, only 6 to 8 pounds are needed. There are about 250,000 red-clover seeds in a pound, and evenly scattered on an acre 1 pound will leave five seeds on every square foot, enough for a good stand if every seed makes a plant. The extra seed is merely insurance, but

this is valuable insurance. The conditions of seed, seed bed, and weather are perhaps never ideal, and allowance must be made for many chances of loss. Therefore, the more seed used, up to, say, 20 pounds per acre, the better the chance for a stand. Too little seed is used more often than too much, and unless seed is extremely high the extra dollar or so spent per acre to insure a stand of red clover is money well invested.

When seeded with spring grain the clover seed is put in at the same time as the grain, but the grain is planted at a greater depth than the clover. On heavy land clover seed should be placed not more than an inch deep, but on light soils 1½ to 2 inches. The companion crop, especially if it be oats, should be seeded at only one-half to two-thirds the usual rate if the clover is to have a good chance for success.

The advantage of using a companion crop is that a grain crop is produced, avoiding the loss of the use of the land for a season, and, too, the grain keeps down the weeds. The stubble of the grain also serves as a winter protection to assist in catching and holding the snow, which otherwise might drift from the field and render the clover plants more likely to be winterkilled. However, the companion crop interferes somewhat with the growth of the clover, and on land where a stand of clover is badly needed and hard to get, it is better to prepare a good seed bed and sow the clover alone. Clover is sometimes seeded in corn at the last working, and this practice has been found very successful in parts of New England. Generally it is risky, since success depends upon good rains coming at that particular time.

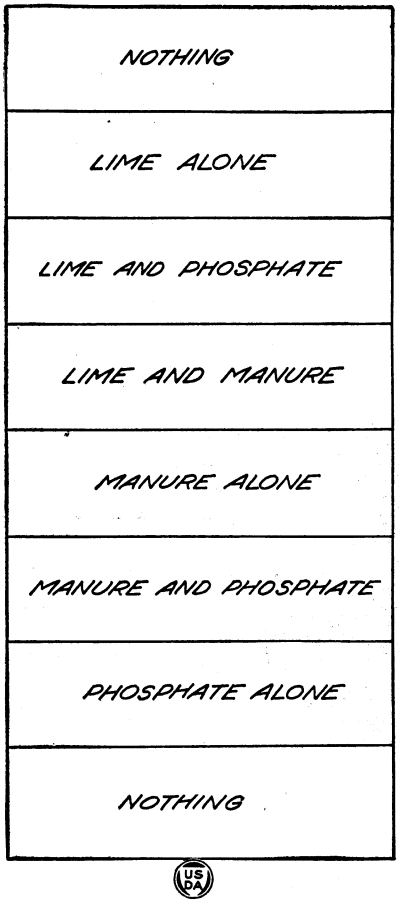


FIG. 9.—A simple experiment outlined to show what the land needs to grow clover.

As far north as central Indiana late-summer seedings are quite successful. Seeding in late summer has the advantage that the grain stubble can be plowed and thus the Hessian fly, wheat jointworm, and other insects destroyed. Of course it means more work, and only a study of local conditions can determine whether such practice will be economically justifiable. When seeded alone clover should be put on fairly clean land. Spring or early-summer seeding without a companion crop can not be practiced on very foul land, as the weeds will get the best of the clover; but when the weeds are not too thick they

may be held back by clipping. The method adopted in any locality must depend on the rotations followed and the labor and weather conditions in each place. It may be emphasized here, however, that to get a good stand the clover must have a fair chance. As usually seeded, too little attention is paid to the weakness of the young clover plant and to its needs. In the clover belt clover is important enough to warrant special care in selecting the seeding method best suited to the special soil and to the other conditions prevailing.

INOCULATION OF RED CLOVER.

In order to make its best growth, the red-clover plant must be supplied with nitrogen-gathering bacteria on its roots. The tubercles containing these bacteria are shown in Figure 3. Fortunately, this crop has been grown so long in this country that most soils appear to be fairly well supplied with these germs, and usually no artificial application of them is necessary. When the clover is being tried as a new crop in a section it often does not become well inoculated until it has been grown for two or three seasons on the same piece of land, after which natural inoculation takes place and good crops are grown without further difficulty. When seeding clover upon land for the first time, it is well to provide for artificial inoculation, but after clover is established on a farm this procedure is usually unnecessary. This artificial inoculation may be accomplished either by scattering soil from some old, healthy, weed-free clover field or by the use of pure cultures.[5]

TREATMENT THE FIRST SEASON.

When seeded with a grain nurse crop no special treatment is given the clover the first season. It develops in the stubble after the grain has been cut and occasionally may afford some pasturage in the fall. If the late summer be especially favorable sufficient growth may be made for a cutting of hay, and in some cases a crop of seed has been secured. The stand, however, is likely to be injured by the cutting, and it is usually best to clip back the growth to check the development of the plants. When seeded in the fall in corn or with rape one or two crops may be expected the next season. It is usually not advisable to pasture spring seedings the same season with sheep or hogs, as they are likely to injure the young plants. Pasturing with cattle is less injurious.

TREATMENT THE SECOND SEASON.

Common red clover lives as a rule but two years. The second season the first crop is usually cut for hay and the second crop for seed. The aftermath, or rowen, is then pastured or plowed under. In sections where the season is not long enough to permit the clover to set seed after a full hay crop has been harvested, it is necessary if seed is desired either to pasture back the first crop of clover or to cut

[5] A limited quantity of pure culture for inoculating legume seed can be obtained free from the Office of Soil Bacteriology of the Bureau of Plant Industry, United States Department of Agriculture. Full directions for using the culture accompany each bottle. Directions for inoculating by the soil-transfer method can also be obtained from the office mentioned.

it early when just coming into bloom, rather than to wait until it is in full bloom, as is usually recommended. When mixed with timothy the stand is often allowed to remain three or four years with the clover gradually decreasing. The increase of pests, such as root borers and fungous diseases, makes it undesirable to try to keep a red-clover stand for more than one crop season. Even on the irrigated fields in Idaho such a practice seldom pays and is not to be recommended.

HANDLING THE RED-CLOVER CROP.

RED-CLOVER HAY.[6]

Time of cutting red-clover hay.—In order to obtain the best hay, the clover crop should be cut as a general rule when just past full bloom. At this stage a maximum of protein and dry matter is present; the leaves are still intact and the stems green. After this stage the leaves begin to fall and the protein content is in other ways reduced. It frequently happens, however, that due consideration for the success of the second crop, which is ordinarily allowed to stand for seed, makes it necessary to cut the first crop somewhat earlier than at the best having stage in order to avoid injury from certain insect enemies. The disadvantage of cutting for hay before it is in full bloom is that the plants are then quite sappy and considerably more difficult to cure into a good quality of hay.

Methods of harvesting red-clover hay.—The methods of harvesting red-clover hay vary somewhat in different sections of the country. It is desirable to handle the hay so that it will reach the barn or stack with the least possible exposure to the weather and the minimum loss of leaves. Clover should not be allowed to become too dry in either the swath or the windrow, else the leaves will crumble, resulting at best in a very dusty hay, to say nothing of the loss of much of its nutritive value.

The secret of successful haymaking lies in rapidly reducing the natural moisture of the plant from 70 or 75 per cent to 15 or 20 per cent. As soon as the plants are cut the leaves lose water and draw on the stems for more. The first sign of this is when the leaves wilt. If they dry too fast because of a hot sun the leaves are killed prematurely; they stop pumping water out of the stems, become brittle, and break off easily, resulting in loss. Keeping the leaves alive and giving all the plants in the swath as nearly an equal chance as possible to get rid of moisture is the whole art of curing hay. Hence, the value of the tedder, if used before the top leaves get too dry. This machine stirs up the cut clover and gives all the leaves a chance to dry evenly and rapidly.

If the hay can be cocked before the leaves are entirely dry the movement of the water from the stems through the leaves will continue. When the leaves become well wilted in the swath the clover should be raked into windrows and then bunched into cocks when the hay is about half dry. Each cock should contain only enough hay so that two men can place the entire cock on the wagon at once, as in this way the loss of leaves due to handling is reduced to a

[6] For the details of handling hay crops, consult Farmers' Bulletins Nos. 943, Haymaking, and 987, Labor-Saving Practices in Haymaking.

minimum. Where a prime or choice quality of hay is desired and the rains are frequent, hay caps for the cocks and canvas covers for any outside stacks are valuable devices. These hay caps can be made from a 40-inch square of canvas or duck and may be held in place by small weights attached to each corner. Cement weights about the size of a baseball which may be attached to the hay cap by means of a hook and eye are satisfactory.

One successful method of curing hay is to cut the clover when half the blossoms are dead. The mower is run the entire day. The next morning, after the dew is off, the hay is raked into windrows, put into medium-sized cocks, and allowed to remain for 24 to 36 hours. The hay is forked over once to prevent heating and is then put in the barn. In threatening weather the hay is put into the barn at the end of 24 hours, but it is preferable to leave it in the field for a somewhat longer time.

Another method which has been successful under favorable conditions is to mow as soon as the dew is off, endeavoring by 11 o'clock to have enough cut to last the haulers from 1 to 5 o'clock in the afternoon. The newly cut clover is shaken up with a tedder before noon. At 1 o'clock it is raked into windrows, immediately bunched with the rake, and hauled into the barn. By this method the hay remains warm and free from outside moisture. The hay must be put in before 5 o'clock or the falling dew will deposit sufficient moisture to cause the hay to mold during storage in the barn. Handled in this way clover loses none of its leaves; but it is necessary to use extreme care to prevent having any outside moisture on the hay or heating in the mow is liable to take place. For this method to be a success excellent haying weather is necessary.

Importance of the leaves for hay.—The leaves are much richer in protein than the stems. While they constitute on an average only about 40 per cent of the total weight of the plant, they contain nearly two-thirds of the protein of the whole plant. Owing to improper methods of harvesting and to untimely rains one-half of the leaves may be lost, thus resulting in a marked deterioration in the feeding value of the hay. Table 1 shows the results of the analyses of hay from a single plant of red clover cut when one-fourth the blooms had turned brown and cured under cover.

TABLE 1.—*Results of analyses*[1] *of the different parts of a dry red-clover plant.*

Constituents.	Heads.	Stems.	Leaves.	Leaf-stalks.
Protein.....per cent..	18.25	8.06	24.63	11.16
Moisture.....do....	9.99	8.02	8.70	8.88
Ash.....do....	7.20	5.67	8.39	8.02
Ether extract (fat).....do....	2.86	1.25	5.00	2.18
Crude fiber.....do....	10.29	34.94	13.36	13.08
Nitrogen-free extract.....do....	51.41	42.06	39.92	56.68

[1] Analysis made by the Bureau of Chemistry.

Stacking red-clover hay.—The same general rules used for stacking other hays apply to the stacking of red-clover hay; but it must be remembered that red clover sheds water much less readily than the grasses and for this reason greater care is necessary in building and

protecting the stack from the action of rain. It is advisable to build some kind of foundation for the stack. This foundation may be composed of poles or rails or some less valuable hay. By care in stacking, a comparatively large bulge may be put on the sides of the stack. This reduces the proportion of the hay in the stack bottom and causes the rain to drain off at some distance from the base of the stack. By keeping the middle full and well trampled the hay will settle in such manner as to cause the water to run off rather than into the stack. As red clover absorbs moisture readily the hay which lies next to the ground is almost sure to be spoiled. If canvas covers are not available for covering hay which must be left outside, it is an excellent plan to top the stacks with green grass, straw, or millet. After the stacks have settled they should be retopped with more grass or straw, placing an additional layer as far down the sides of the stack as possible. This materially reduces the quantity of clover hay exposed to the elements.

When the hay is stacked or stowed away in the barn in a slightly damp condition it is sometimes the practice to mix salt with it for the double purpose of salting the animals and of preventing mold. If the clover must be put up when thought to be a little too green, alternating layers of straw will do much toward absorbing the excess of moisture.

Brown clover hay is made by stacking or mowing away the hay when it has just reached the wilting stage. The air is excluded and it becomes a compact mass. The hay must be free from external moisture if heating is to be avoided. There is therefore some danger of spoiling when this method is used by those unfamiliar with the process. This method has a further disadvantage in that the hay is very heavy at the time when it must be handled for stacking.

Spontaneous combustion of red-clover hay.—When red-clover hay is stacked or mowed with any external moisture on it, such as dew or rain, heating is inevitable until not only the hay itself is damaged, but the heating process may go so far as to cause the entire mass to ignite and burn the stack or the barn in which the hay has been placed. The absence of air from the mass of heated hay in a barn is often the only thing which prevents it from breaking into a flame, and such instances are made manifest the following winter by finding charred masses within the interior of the mow.

RED CLOVER FOR SILAGE.

Silage has been made from red clover as from other legumes, but the process is always risky and rarely satisfactory. The relatively low sugar content of clover results in poor fermentation, and clover silage is likely to be slimy and unfit to feed. There is also a considerable loss in nutrients. On the whole, the making of silage out of red clover can not be recommended. When necessary to do so it is best to mix the clover with grasses, to cut it fine, and to trample carefully.[7]

RED CLOVER AS PASTURE.

Red clover is a most excellent pasture for all livestock, especially while they are growing. For pigs it should be supplemented with a

[7] See Farmers' Bulletin 578, The Making and Feeding of Silage.

small grain ration, as this will induce much more rapid gains. The early growth of red clover is less nutritious, pound for pound of green matter, than when near or at the blooming stage, since in the early stages of growth it is high in moisture content, thus requiring the animals to eat relatively larger quantities. Furthermore, close early pasturing is injurious to the stand of clover.

Ordinarily red clover will furnish some pasture during the first fall after spring seeding. It should not be too closely grazed at this time, else the succeeding season's hay crop may be decreased. The plants should rather be allowed to go into the winter with some growth upon the crowns in order to prevent winterkilling and also to enable them to store up material in the roots for an early vigorous growth the following spring.

Bloating.—When pasturing cattle or sheep on red clover, care must be taken not to pasture when the animals are very hungry, especially when the clover is young and succulent or when wet with dew or rain, as bloating may result. Should bloating occur, several remedies are usually at hand which will afford material relief. A large bit, the diameter of a pitchfork handle, may be tied in the mouth; a piece of rubber tubing may be passed through the mouth to the first stomach; or, as a last resort, the animal may be tapped to allow the escape of gas. For this purpose a trocar, such as is used by veterinary surgeons, is best; but in the absence of this a small-bladed knife may be used to make the incision about 6 inches in front of and slightly below the left hip bone. A straw or quill may be used to permit the escape of gas. Care should be taken not to allow the straw or quill to work down out of sight into the incision.[8]

When cattle are pastured on any crop that may cause bloating they should have free access to some form of dry roughage, such as hay, oat straw, clover straw, or corn fodder.

RED CLOVER AS A SOILING CROP.

Where pasturing is impracticable, red clover is often used as a soiling crop; that is, cut and fed green to livestock. Feeding in this way reduces or eliminates the danger from bloating which attends the use of red clover as pasture. It makes a good early feed, is palatable, and from 6 to 10 tons of green feed per acre is not an unusual yield.

RED CLOVER AS FEED.

All farm animals require protein in some form in order to make their best growth or to produce the best results either in the form of milk and butter, as in the case of dairy stock, or as eggs, in the case of poultry. Such roughage as corn stover and ordinary grass hay is low in the necessary protein. On many farms this protein is supplied by feeding concentrates, such as bran, oil meal, or cottonseed meal; but these concentrates are expensive and on most farms should

[8] See Diseases of Cattle, a special report of the Bureau of Animal Industry, United States Department of Agriculture, which can be purchased from the Superintendent of Documents, Government Printing Office; price, $1.

be in large measure replaced by a leguminous forage crop, such as red clover, which can be grown on the place.

Red clover is one of the most nutritious of forage plants, either in the green state or cured as hay.

Table 2 shows the average quantities of dry matter, protein, carbohydrates, and fat in 100 pounds of a few standard feeds. It will be noted that the clover hay contains more than twice as much protein as timothy hay and is therefore a more valuable feed, especially for young stock and for dairy cows.

TABLE 2.—*Digestible nutrients in red clover and other forage crops.*[1]

Kind of forage.	Dry matter in 100 pounds.	Digestible nutrients in 100 pounds.		
		Protein.	Carbohydrates.	Ether extract (fat).
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*
Fresh clover	28.0	2.6	12.2	0.7
Fresh alfalfa	27.1	3.6	11.8	.4
Clover hay	87.1	8.3	38.6	2.0
Alfalfa hay	91.7	11.5	39.4	1.1
Timothy hay	87.5	3.3	41.6	1.3
Cowpea hay	90.3	11.9	34.5	1.1
Wheat bran	90.4	12.5	42.8	2.6
Shelled corn	87.1	7.1	66.5	3.7

[1] Figures furnished by the Bureau of Animal Industry.

RED CLOVER IN MIXTURES.

It is very often advantageous to seed red clover in a mixture with other clovers and tame grasses. The root systems of the different species are not the same, and as a result the soils of both the upper and lower layers are more fully occupied than they would be by a stand of a single crop. In case the stand is to be used for pasture, a mixture will usually insure a better succession of good pasturage than would the use of any single crop; that is, by proper selection of the constituents of the mixture it is possible to obtain a pasture which will provide for early as well as late grazing and at the same time give fair returns during the heated months of summer.

By far the most common mixture is red clover and timothy (fig. 10), but the practice of adding alsike clover to this mixture is increasing. Whenever any difficulty is experienced in getting a stand of red clover it is a good plan to replace about half the red-clover seed with an equal weight of alsike-clover seed. While alsike clover will not yield as heavily as red clover when the latter does well, it is more certain to catch on soils which are poor in lime. In the winter-wheat section, except in the South, the timothy is seeded with the wheat and the clover on the wheat the next spring. In the spring-wheat section the timothy is seeded with the red clover at the same time the wheat is sown, mixing 10 to 12 pounds of timothy with 8 to 10 pounds of red clover or of red clover and alsike clover. The timothy is longer lived than the red clover, and as a result the proportion of timothy in the mixture of the hay increases very rapidly

after the second season. Ordinary red clover matures about two weeks earlier than the timothy, and for this reason mammoth clover,

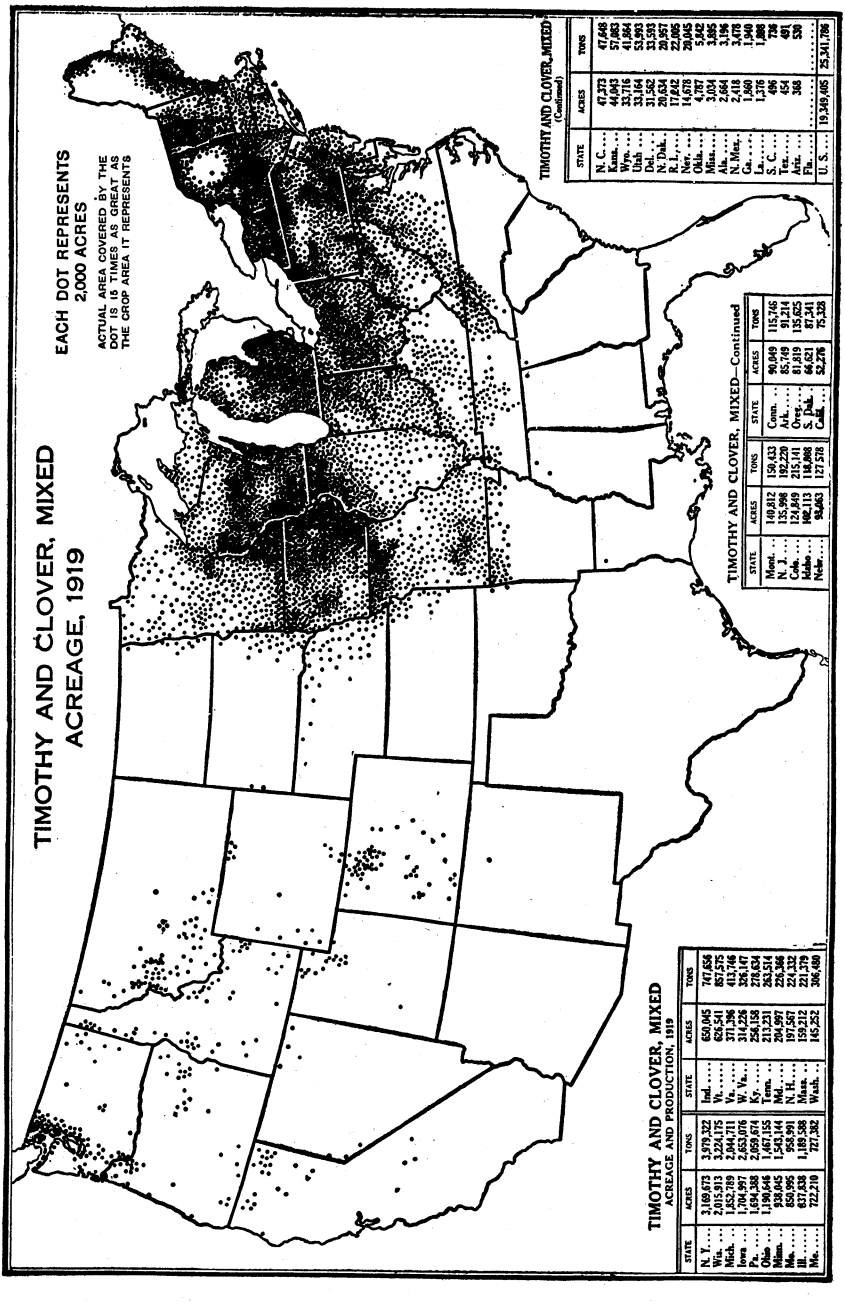


FIG. 10.—Outline map showing the acreage in 1919 of mixed timothy and clover, which constitute the standard mixed hay throughout the northern part of the United States as far west as Iowa and Minnesota.

being about two weeks later, is frequently used for seeding in mixtures with the timothy.

For commercial purposes red clover and alsike clover are much preferred, particularly when mixed with timothy. The trade objects to mammoth clover on account of its coarse texture and somewhat woody nature. The United States grades for timothy and clover and their mixtures class mammoth clover with other legumes, of which a total of only 5 per cent is permitted in any grade. Mixtures of red clover and alsike clover with grasses other than timothy are also discriminated against both in price and demand.[9]

Other mixtures suitable for hay are red clover combined with orchard grass, tall meadow oat-grass, and a small admixture of alsike clover. In any low spots in the meadow it is advisable to replace the orchard grass with redtop and at least half of the red clover with alsike clover. On rough-land pastures red clover may also form a minor constituent of a regular mixture of bluegrass and white clover.

The importance of the timothy-clover mixture may be judged from the figures in Table 3, in which the acreages of all the tame-hay crops harvested in 1909 and in 1919 are compared with the acreages said to have been in timothy and clover. The figures were calculated from data in the census reports for 1910 and 1920.

These figures may not show the exact relation of timothy and clover hay to all the tame hay as determined by the United States Department of Agriculture hay grades, since wherever the clover has failed or nearly failed in a mixed seeding pure timothy hay would result. However, it is probable that with alsike clover used largely in the mixtures the acreage figures will apply fairly well to the hay as graded.

TABLE 3.—*Ratio of the acreage of timothy and clover to the total acreage of tame-hay crops in 1909 and 1919.*

States.	Ratio to tame-hay crops (per cent).		States.	Ratio to tame-hay crops (per cent).	
	In 1909.	In 1919.		In 1909.	In 1919.
New England	50.13	59.1	Kentucky and Tennessee	22.07	19.72
Middle Atlantic	60.23	60.3	East North Central	41.33	48.9
Delaware, Maryland, Virginia, and West Virginia	46.67	51.66	Minnesota, Iowa, and Missouri	52.79	47.76

RED CLOVER AND SOIL IMPROVEMENT.

One reason for the great popularity of red clover is the ease with which it lends itself to the rotations which have long been practiced in the sections to which it is adapted. While sweet clover is replacing red clover in some localities and alsike clover is used in whole or in part on many soils on which red clover no longer does well, generally speaking red clover is the standard leguminous crop in the rotations in the northeastern quarter of the United States.

On farms where cattle are kept the clover, of course, makes the standard hay, and on such farms the first crop is cut for hay and the second may be allowed to make seed or may be turned under. On

[9] This paragraph was furnished by the Chief of the Bureau of Agricultural Economics.

good soils and where clover is regularly successful in the rotation the turning under of this second growth will usually keep the soil in good condition so far as organic matter and nitrogen are concerned. P. E. Brown, at the Iowa Agricultural Experiment Station, has shown that red clover may take more nitrogen from the air than is removed in the hay and that therefore the mere turning under of the roots and stubble may improve the soil. The Delaware Agricultural Experiment Station found that 30 per cent of the money value of the fertilizer contained in red clover was in the roots. Red clover is therefore better suited than most legumes to a place in the rotation which requires the removal of the parts above ground and the use of the stubble and roots for keeping up the yields of other crops. However, it must not be thought that such a system can be continued indefinitely, except possibly on very rich soils. It has been found that on many soils the turning under of the roots and stubble only once in three years is not enough to maintain yields.[10] It is chiefly this soil-improving quality that makes red clover so valuable as a rotation crop. Other crops can be used for hay, but no other crop lends itself so well to hay production and to soil improvement in relatively short rotations.

A red-clover field may be handled in various ways, but in view of the fact that clover is grown not only for hay but for soil improvement it will be pertinent to note the different methods of handling the clover with reference to the good of the land. The entire crop may be turned under for soil improvement. This is rarely done, but the manager of the Notre Dame University farm (South Bend, Ind.) does this regularly on the poor sandy soil of that place and insists that it pays to do it. The next best method and the one that will be applicable in most cases is to cut the first crop for hay, to be fed on the farm, and to turn under or to pasture the second crop. Another method that also yields good results and is especially useful where the pasture is not needed is to cut the first crop for hay and the second for seed and to return the straw to the ground. The objection to returning the chaff to the ground is that this gives a chance for the clover-seed chalcis fly to develop in the light seed that has been blown out with the chaff and so tends to increase the damage from this pest. From the standpoint of soil improvement the most unsatisfactory method is to cut both crops and leave only the stubble of the second crop to be turned under. However, even in such a case, especially if the second crop is cut for hay as early as possible and the field not plowed until the next spring, there will be considerable growth to add to the soil. Where the hay is not needed an excellent method is to pasture until late May or clip the field and then allow a seed crop to grow. By this method damage from insects is reduced to a minimum, and a fair to good seed crop may be confidently expected. The aftermath can then be plowed under or grazed if pasturage is needed.

RED CLOVER IN ROTATIONS.

In the northeastern United States the common rotations include a cultivated crop, a small-grain crop, and clover, or clover and grass. These rotations may be of various kinds and may include one or two

[10] See Farmers' Bulletin 1250, Green Manuring.

crops of corn or other cultivated crop, one or two crops of small grain, of which one or both may be fall or spring seeded, and the clover or clover and grass stand may be left for one, two, or more years. In such rotations clover is commonly seeded with the small grain and turned under for the cultivated crop, usually corn. This procedure starts the clover without extra cost and with the benefit of whatever fertilizer is applied to the small grain, and the sod in decaying affords a steady supply of nitrates to the corn throughout the summer. The utilization of the sod in this way is the most economical and efficient. In long rotations clover may be grown but one year in four or five. Unless the soil is exceptionally rich such rotations will in time exhaust the organic matter in the soil and with it the nitrogen, and the land will run down and presently refuse to grow clover.

In a system of grain farming the chief purpose of the clover in the rotation is to help in maintaining soil productivity. On such farms mammoth clover is advantageous, since a crop of seed can be taken as a cash crop and the straw, stubble, and roots turned under, in this way removing the least possible quantity of organic matter from the field and still getting some return. On such farms, too, sweet clover of late years has replaced red clover to a considerable extent. Seeded with a small grain, the sweet clover is turned under the following spring for corn. Besides these more or less standard rotations in which clover is used, it is sometimes seeded in corn or alone on the disked cornland in spring, to be turned under at some later time for another crop of corn. In Minnesota red clover is often seeded with spring grain and turned under the same fall, when the land is prepared for the next grain crop.

RED-CLOVER SEED PRODUCTION.

Red-clover seed is produced in small quantities on a large number of farms throughout the clover area. In some sections, as in some of the Intermountain States, the production of seed is a regular business, but generally the production of clover seed is incidental. If conditions are right and there seems to be a good setting of seed the field is left for seed. If there is not a good prospect for a seed crop the clover is turned under, or it is cut for hay if this is needed or if the price is high enough to warrant making hay for sale. In some sections red-clover seed is taken from the first crop, but this practice is confined to special localities. A number of factors influence the yield of seed, but most of these are as yet imperfectly understood. It can be said in general that the ideal conditions for seed production are the following: (1) A strong, vigorous recovery after haying; (2) clear, warm, but not extremely hot weather at the time the second crop is in bloom; (3) an abundance of bumblebees and other pollinating insects; (4) the absence of injurious insects, such as the clover-flower midge and the chalcis fly; and (5) good harvesting and curing weather. The second, third, and fifth of these factors are wholly beyond human control and sometimes exert a profound effect. A hot wave when the clover is in full bloom may destroy a seed crop that looks promising. A vigorous recovery depends somewhat on weather conditions, but also on the stage of ripeness at which the hay

is cut. If this is allowed to get overripe the plants do not recover well, while the earlier the hay crop is cut the better for the seed crop. As a specific instance it may be cited that mowing was commenced on one side of a 40-acre clover field when the plants were two-thirds in bloom. Several days were required to cut the field and the last of the clover was not cut until the plants were just past full bloom. The effect of this time of cutting on the seed crop was remarkable in that the early cutting induced the second crop to produce seed at the rate of 5 bushels per acre, whereas the cutting a week later resulted in a subsequent seed yield of only 2 bushels. The difference in the value of the preceding hay crop by reason of the early cutting on the one side was probably not more than 20 per cent, whereas its increase of the yield of seed was more than 100 per cent.

Early cutting will also help to control the injurious insects mentioned above in connection with the fourth factor, as the first brood of the season will be destroyed in the hay and there will be few adult females to bother the seed crop. The same object may be attained by pasturing the clover in the early part of the season and taking a seed crop only.[11]

In the northern portion of the northern tier of States the short growing season will not usually permit the first crop to reach full bloom and still allow time for a seed crop to mature. For this reason it is usually necessary to pasture the crop or cut it earlier than would otherwise be desirable. If a full cutting of the first crop of clover is made for hay and the second left for seed, the seed yield is likely to be disappointing on account of the lack of suitable growing weather for the seed crop. In the latitude of northern Michigan the clover may be pastured until June 18 or 20 in normal seasons and then allowed to produce seed. If livestock for pasturing is not available, the clover may be clipped back about the middle of June with equally good results. Even when the land is pastured it is a good practice to run the mower over the field after the stock is removed, to clip back any bunches which may be left by the stock. In this way the seed crop will mature much more evenly over the entire field.

ESTIMATING THE PROBABLE SEED CROP.

Inasmuch as clover straw is of little value as feed, if the crop is allowed to go to seed a decision must be made when the field is a little past full bloom as to whether the second cutting should be allowed to stand for seed or be used for hay. It is usually possible to estimate with fair accuracy the probable seed production by the time the plants are well out of bloom. If examination of the field shows a uniform stand of a goodly number of heads with an average setting of 25 to 30 seeds to the head, it may be taken as an indication of a sufficiently good crop to pay to cut it for seed, as under normal conditions this indicates a yield of 1 to 2 bushels per acre. If the heads which are turning brown show less than 20 seeds to the head, it will usually be better to cut the crop for hay, even though it is a little too late for the best quality of hay.

[11] For an extended account of the clover-flower midge, see Farmers' Bulletin 971, The Control of the Clover-Flower Midge.

HARVESTING AND HULLING RED-CLOVER SEED.

The best time to cut red clover for seed is when the heads have turned brown and the flower stalks deep yellow and the seeds have begun to show a distinct violet color. If cutting is delayed until the heads are black or until the seeds have completely colored, the loss of seed from the breaking off of the heads is certain to be heavy. If the stems are heavy and full of sap, cutting can be done earlier than if the stems are short and dry, as the abundant sap will ripen the seed. When cut early, before the leaves are dead, the stems dry better and cure more quickly. Sappy stems when cut after the leaves are dead cure slowly and therefore cutting should be done before the leaves reach that stage.

Various machines are used for cutting clover for seed, but the most common are a mower with a windrowing attachment and a

FIG. 11.—A mower with attachment which leaves the cut clover in windrows, out of the path of the horses on the next round.

mower with a bunching attachment. The latter is best when the clover to be cut is dry, since the cut clover is then handled but little. The windrowing attachment is the most popular, as it puts the cut clover out of the way of the horses on the next round. (Fig. 11.) The old self-rake reaper is also popular. Farmers use various methods and different machines, but the principle to be kept in mind is to handle the crop between cutting and hulling as little and as carefully as possible. Every time a clover head is broken off some seed is lost.

The cut clover is allowed to lie in the field until partly cured and is then put into cocks. These should be small, not more than 2 or 3 bushel basketfuls in size. Large cocks will not dry in the center without being pulled apart, and that involves risk of loss. A somewhat prevalent idea is that the clover must rot in order to hull well, but this is not necessary. The important thing is that it must be thoroughly dry. Damp clover is tough and does not handle well.

The principles involved in the successful handling of the clover-seed crop are: (1) Cut when the seed is ripe enough, but when most of the leaves are still alive; (2) handle no more than is necessary; and (3) hull as soon as possible after the clover is thoroughly dry.

Any tools or methods that make it possible to handle the crop in this way are good tools and good methods. It is the usual practice to hull from the field, but if the clover must lie for weeks before a huller can be secured it is much better to put the dry clover in the barn or to stack it than to leave it in the field exposed to all sorts of weather. When the seed crop is stacked it is very important that the clover be bone dry; otherwise, it will remain damp in the center and will have to be torn apart and spread before hulling. This extra handling will entail the loss of seed. To protect the base of the stack 6 to 8 feet of dry straw should be placed on the bottom, and the stack should be carefully covered with grass hay or with a stack cover. When stowed in the mow the only care is to have the clover bone dry before bringing it inside. In damp clover a considerable quantity of seed may be lost by sprouting; in fact, more than would be lost by handling the crop during hauling and stacking. Besides the actually sprouted seed in damp rotting clover there is also a lot of seed that swells and is ruined. Many of these seeds are later blown out as light seeds, while others lower the value of the entire crop because they are brown and shriveled.[12]

Hulling clover is commonly done by special clover hullers. There are also clover-huller attachments to grain separators. A clover huller is simply an ordinary threshing machine equipped with an auxiliary cylinder and concave with rasps or other devices for rubbing off the hulls from the threshed seed. The huller will not do good work when the clover is at all damp even from dew; hence six hours is usually found to be a good day's run when hulling from the field.

UTILIZATION OF CLOVER STRAW.

After the seed has been removed the clover straw is too unpalatable to be of much value as feed, though sheep and cattle will pick it over during the winter. It may be scattered on the field from which it was cut with good effect on the land. The chaff may also be used as an absorbent of liquid in stables. It is an excellent plan to apply the clover straw and chaff to thin spots in the fields which are to be in clover the succeeding year. This method materially improves the inoculation and tends to increase the productivity of the clover and other crops.

If the clover is cut for seed and cured without having been rained upon, the straw has some feeding value, but such instances are unusual. When the first crop of clover is cut for seed the straw makes a fair feed.

RELATION OF POLLINIZING INSECTS TO THE PRODUCTION OF RED-CLOVER SEED.

Numerous experiments have shown that if the heads of red clover are bagged to exclude insects little or no seed is produced, indicating that without external assistance of some kind the red-clover plant

[12] See Farmers' Bulletin 676, Hard Clover Seed and Its Treatment in Hulling.

is unable to set seed. It is possible that some seed may be produced when the pollen from a flower is placed on the stigma of that flower or on the stigma of another flower of the same plant. As a rule, however, red clover is self-sterile and for practical purposes is wholly so. In the open field the flowers are cross-pollinated. Bumblebees are commonly supposed to be the most efficient agencies in the pollinization of red clover. When the bee alights on the clover head its weight presses down upon the keel, forcing out the stigma (female), which becomes dusted with the pollen (male) that is already adhering to the under surface of the bee. Other species of wild bees, as well as honeybees, especially the long-tongued Italian strain, also play a great part in pollinating red clover. It has been shown experimentally that even when honeybees and smaller insects only had access to clover a good seed crop was set.

VARIETIES OF RED CLOVER.

In North America there are but two standard varieties of red clover, medium and mammoth, though a third variety has been developed in Tennessee because of its resistance to anthracnose. This disease-resistant variety is in all other respects like the common red clover. Medium, June red, or common red clover is the standard clover in the United States and Canada. It is an extremely variable plant, but no special varieties except the disease-resistant one mentioned are in use. There has been some work done on selection, especially in Canada, but no seed of these new varieties or strains has yet appeared in the trade.

Mammoth clover, also known as Sapling clover, Big English, Pea Vine clover, Bull clover, and Perennial clover, is only a form of the ordinary red clover and is known botanically as *Trifolium pratense perenne*. It is not the "zigzag clover" of northern Europe, known as *Trifolium medium*, which latter name has often been misapplied to mammoth clover.

Mammoth clover differs from medium red in being about two weeks later to mature and in being under similar conditions larger and coarser. It is commonly more hairy and in the autumn of the first season blooms little or not at all. At this stage it can usually be distinguished in the field by its closer adherence to the low rosette habit. Only one crop of mammoth clover can be harvested each season, since it does not recover quickly. On the other hand, it is generally longer lived than common red clover and so is often used in pasture mixtures.

On low ground the stems of mammoth clover are likely to become somewhat woody. It grows less rank on poor soils, where it is ordinarily grown rather than on the heavier soils. Furthermore, on the poorer soils it is excellent as a seed-producing crop, being used in a rotation of corn, grain, and clover each one year. The mammoth clover is allowed to stand for seed, and no attempt is made to utilize the straw other than as a fertilizer for the land. The late maturity of this clover enables it to avoid many of the insect pests which greatly injure the fields of ordinary clover. This item is important in reducing the injury from the insects which play havoc with the successful production of seed of the ordinary red clover. If grown for hay mammoth clover should be cut when in

early bloom rather than when past bloom, on account of the tendency of the stems to become woody. In the northern part of the tier of Northern States where only one crop of ordinary clover is possible mammoth clover is usually preferred on account of its higher yield.

While some men who have had long experience in the seed trade believe that they can tell mammoth-clover seed from that of common red, there are no absolute distinguishing marks. The seeds are of the same size and coloring, the variations observed in one form occurring also in the other.

Foreign red clovers.—In Europe several varieties or strains of red clover are recognized and are mostly known by the names of the countries or provinces where they are grown. European red clovers usually have smooth leaves and stems and therefore make a cleaner, less dusty hay than the American clovers. However, some European clovers are known to be not adapted to American conditions. So far as tested none of them give returns in this country equal to those from American clovers. The plants raised from seed of southern European regions are not winter hardy in the Ohio Valley and westward, and in the southern parts of the red-clover area they are more readily killed by disease than plants from American seed. Even where the stand of European plants has come through the winter successfully and has yielded a fair first cutting, the stand sometimes completely dies out after the first cutting. In no case has a second cutting compared favorably with the yield from American plants. Of late years much red-clover seed has been imported from Chile, and this has given better results than any other imported seed. The plants are smooth and in tests so far made have yielded a large first cutting. The behavior of the plants after the first cutting is, however, much like that of plants from European seed, and the aftermath and second cutting are likely to be disappointing.

ENEMIES OF RED CLOVER.

The principal enemies of red clover are insects, fungous diseases, and weeds. Under conditions favoring their increase, such rodents as field mice, ground squirrels, and pocket gophers become abundant and cause considerable damage.

INSECT ENEMIES.

Red clover is injured by a rather small number of kinds of insects, although some of these pests may at times be abundant enough to destroy the greater portion of the crop. Many insects which feed to a slight extent on this valuable plant are seldom or never sufficiently numerous to cause appreciable loss. For further information on the principal insect enemies of red clover the publications of the Bureau of Entomology of the United States Department of Agriculture should be consulted.[13]

The clover root-borer.—Great damage has resulted for many years from the work of the clover root-borer (*Hylastinus obscurus* Marsh)

[13] Farmers' Bulletin 942, Controlling the Clover-Flower Midge in the Pacific Northwest; Farmers' Bulletin 971, The Control of the Clover-Flower Midge; and The Clover-Root Curculio, U. S. Dept. Agr., Bur. Entom. Bulletin 85, pt. 3, bibliography, p. 38.

in the clover-producing States east of the Mississippi River. At one time this pest threatened the entire clover-growing industry of Michigan. In recent years this insect has become a serious menace to clover culture in western Oregon and Washington, where the production of clover is of considerable importance. The adult insect is a dark-brown hard-shelled beetle (fig. 12), about one-sixth of an inch long. Its presence is best indicated by the injuries to the root of the clover plant (fig. 13) caused by the larva, or grub, of the insect (fig. 14). The clover root-borer does not usually damage the stand of clover until the summer of the second year, because it is not until the roots of the plant become of considerable size that this pest is capable of living in them. For this reason, where practicable, a three-year rotation is desirable as a means of preventing injury from this pest. The only remedial measure yet suggested is the turning under of the clover stubble as soon as the hay crop is removed, preferably between June 15 and August 1. At this time the root-borers are in an immature stage, and when deprived of their food must perish, as they are incapable of migration. If plowing be delayed until later in the fall, the larvæ will then have become pupæ, or adults, and at this time they may be unaffected by plowing operations. Spring plowing of heavily infested fields has been known to cause severe injury by inducing migration to new clover.

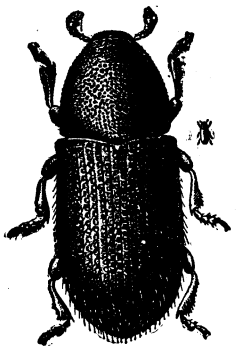


FIG. 12.—The adult insect of the clover root-borer. A natural-size representation is shown at the right.

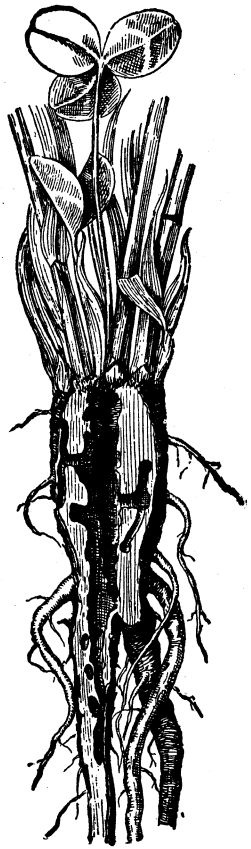


FIG. 13.—Clover root, showing the work of the clover root-borer. (Slightly enlarged.)

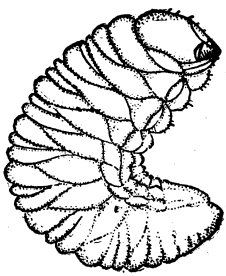


FIG. 14.—The larva (grub or maggot) of the clover root-borer. It is in this stage that the insect does most damage to the clover roots. (Much enlarged.)

The clover-seed chalcis fly.—A little black wasplike insect (fig. 15) about the size of the red-clover seed, known as the clover-seed chalcis fly (*Bruchophagus funebris* How.), may frequently be seen emerging from a recently threshed crop of this seed. At present this insect is one of the worst clover pests in the United States, being largely responsible for many of the low yields of clover seed. The eggs are laid in the newly developed seed before it is entirely hardened; the larva then develops within the seed, which it eats entirely away be-

fore emerging as the adult. (Fig. 16.) As this insect spends the winter to a large extent in the deformed and hollow seed capsules of the clover and alfalfa plants, it is most important that all screenings and débris resulting from the threshing of clover and alfalfa seed be destroyed, preferably by burning, as soon as practicable after the threshing is completed. It is probable that light early pasturing or clipping the first growth in the spring will materially reduce the danger from this pest; by bringing on the seed crop later than usual the destructive work of the insects may be largely prevented.

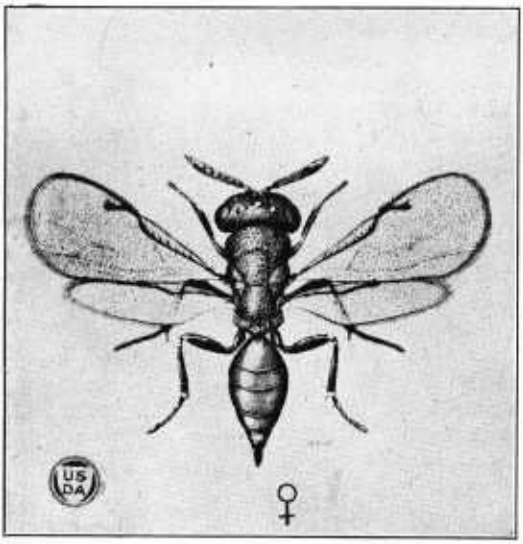


FIG. 15.—Adult insect of the clover-seed chalcis fly. The wings are ordinarily closely folded along the back. (Much enlarged.)

The clover-flower midge.—The seed production of red clover is greatly reduced at times by the work of the clover-flower midge (*Dasyneura leguminicola* L.). (Fig. 17.) The maggots of this insect attack the florets of the clover, thereby causing the distortion and stunting of the blossoms, which often becomes plainly evident throughout an infested field even when viewed from a distance. (Fig. 18.) The adult of this insect is a small mosquitolike fly, closely related to the wheat midge and the Hessian fly. This pest may be controlled by cutting the first crop of clover early enough to

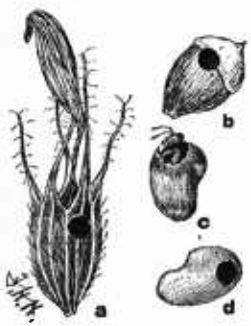


FIG. 16.—Sketch showing the effect of the clover-seed chalcis fly: Calyx (*a*), seed capsule (*b*), and seeds (*c* and *d*). At *c* the mature insect is shown in the act of emerging.

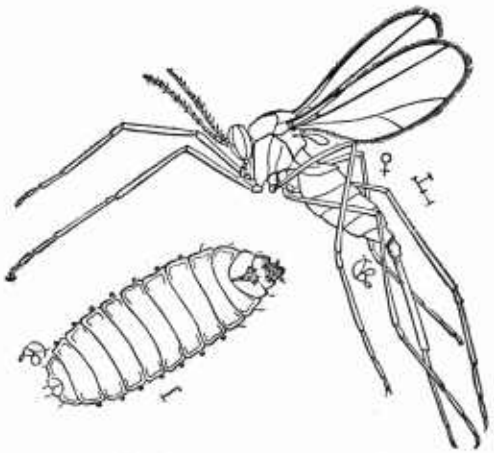


FIG. 17.—Maggot and adult stages of the clover-flower midge. In the clover head the maggot appears as a small red object one-twelfth of an inch in length.

catch the maggots before they are fully fed, thus depriving them of food and causing their destruction. Because of regional differences in the maturity of the insect and the crop, no definite date for cutting can be recommended, although it has been found that the first of June usually is suitable throughout most of the injurious range of this insect. The most satisfactory results are to be obtained, however, by observing the color of the maggots in the infested heads. When their color begins to turn from a creamy white to a salmon pink, the time for action has arrived, and if the pest is to be overcome cutting should occur within a day or two. Most of the larvæ will be killed, and the early cutting of the clover will so hasten the development of the seed crop that by the time such of the first brood as have survived here and there have matured, the blooms of the second crop have become too far advanced for the insects to work in them. A second method may be applied where timothy and clover are grown together. The meadows may be pastured lightly or they may be clipped back with a mower set high. This brings the blooming of the subsequent crop of clover too late for the destructive work of the midge.

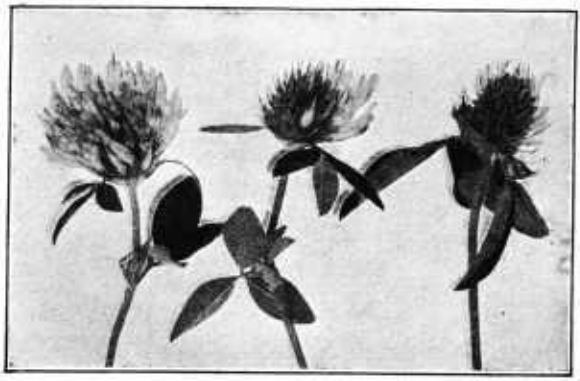


FIG. 18.—Clover heads, showing the effects of the clover-flower midge. The flower head shown at the left is unaffected, the middle head is partly affected, and the head at the right shows all the flowers destroyed by this insect.

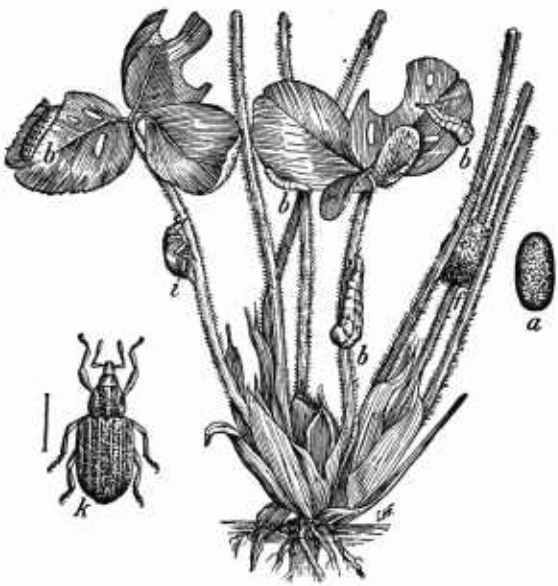


FIG. 19.—The clover leaf-weevil: *a*, Egg; *b*, *b*, *b*, *b*, larvæ feeding; *f*, cocoon; *i*, beetle, side view; *k*, same, back view; (*b*, *f*, *i*, natural size; others more or less enlarged.) Adapted from Riley.

The clover leaf-weevil.—Among the minor enemies of red clover is the clover leaf-weevil (*Hypera punctata* Fab.) (Fig. 19.) The larvæ begin to hatch in the fall and

become full grown in April and May, and the adult insects appear from the last of May until the following October. This insect was formerly especially troublesome in Michigan until a fungous disease of the larva developed sufficiently to hold it in check.

One important effect of the clover leaf-weevil is that it may destroy the early foliage. A little later the clover renews its growth without being permanently injured. This delays the flowering period until after the flower midge has laid its eggs and disappeared. In this respect the weevil may be beneficial. The temporary destruction of the early foliage may lead the grower to believe that his clover field has been killed, and he may therefore plow up the stand, whereas really the injury will prove but slight if the field is left undisturbed. In case of excessive damage, the clover leaf-weevil may be destroyed by spraying the crop with arsenate of lead (powdered), 2 pounds mixed with 100 gallons of water, this quantity to be applied to 1 acre of the crop.

FUNGOUS DISEASES OF RED CLOVER.

A number of diseases attack principally the leaves of the red-clover plant, forming large or small spots of various appearances. The clover leaf-spot appears as a multitude of small black specks on the leaves. The clover rust shows as small reddish brown spots on the leaves. The powdery mildew develops a whitish mass somewhat like a cobweb across the surface of the leaves, and close inspection shows the presence of small black bodies within the meshes. None of these leaf diseases is usually very serious, and when the plants are growing vigorously they are generally able to thrive in spite of the presence of the fungous diseases. Cases have been known, however, where rust damaged the clover as much as 50 per cent. Mildew was unusually abundant in the fall of 1921 and in 1922, but feeding tests conducted at the Tennessee Agricultural Experiment Station showed that mildewed clover could be fed without damage to livestock.

Root-rot occasionally proves destructive to the roots of the clover plant. Stem-rot attacks the stems and is characterized by the presence of hard, dark masses of fungous tissue.

The disease known as clover anthracnose has been observed in a number of States, but its ravages have been observed to be especially disastrous only in Tennessee, where, owing to its prevalence, the seeding of red clover is said to have been practically given up. The disease is first manifested by a series of small purple patches which spread on the stem until if at all badly affected it is completely encircled, causing the death of the plant.

WEEDS.

The seeds of the weeds which are commonly found in red clover are shown in Figure 6. From the standpoint of the clover plant itself buckhorn, foxtail, and crabgrass probably form the worst weeds with which the clover plant must contend. Preventive measures alone are ordinarily practicable, as eradication is too expensive except in the case of especially dangerous weeds or weeds large enough to be readily removed just before they mature their seed crop. Thistles, dock, and wild-carrot plants should be removed.

Dodder is one of the worst weeds so far as red clover is concerned. The accompanying illustration (fig. 20) indicates the general appearance of the yellow threadlike vines which attach themselves to

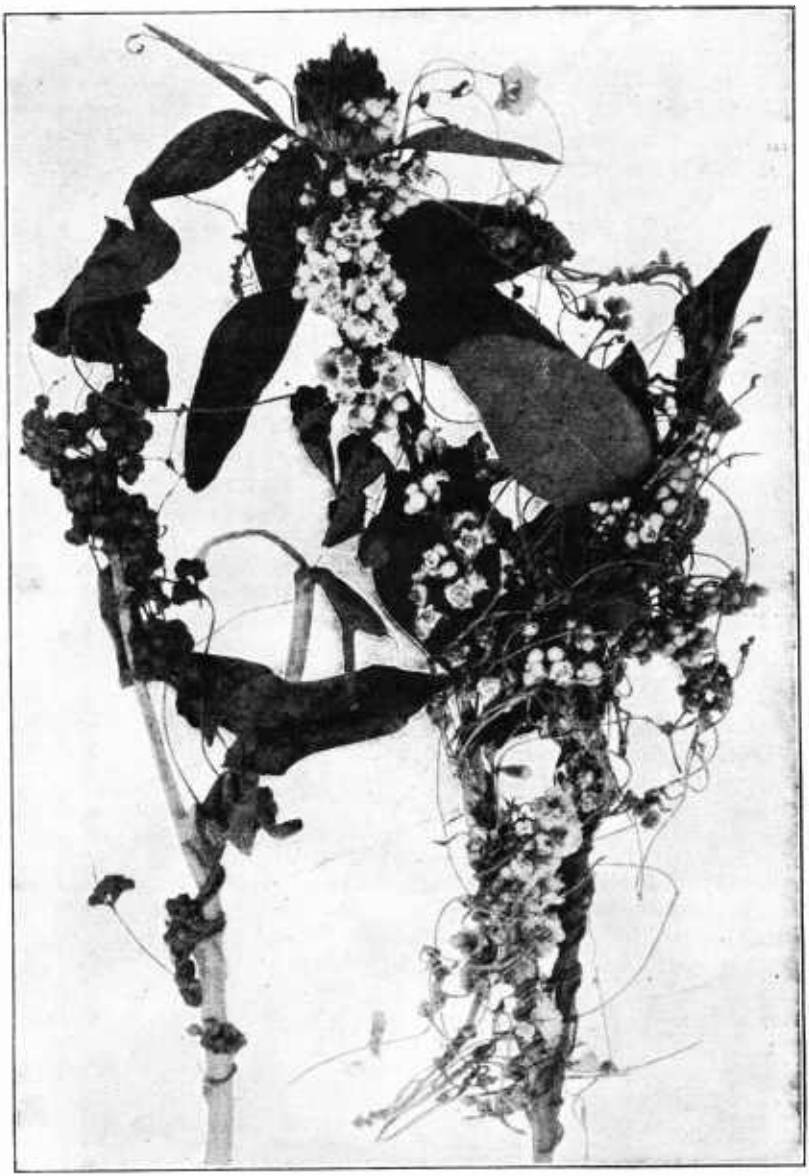


FIG. 20.—Field dodder on stems of red clover. At the right the dodder is shown in flower; at the left, in the mature or seed-producing stage.

the clover plant. The dodder seeds germinate in the ground shortly after the clover seeds sprout. The yellow threadlike stem of the dodder soon firmly attaches itself to the young clover plant, after

which the stem connecting it with the ground withers away and the dodder lives thereafter entirely on the clover plant. Dodder is very difficult to eradicate when once established, and for this reason great care should be taken to avoid introducing it with the red clover at seeding time.[14] Close grazing has been recommended as being effective in holding dodder in check. If it appears in isolated spots throughout the field, it is advisable to cut the affected area as low as possible before any seed is produced on the dodder and to remove all cut material from the field. Destroying the dodder by burning with inflammable materials or by spraying with sodium arsenite are methods used in Idaho, where dodder is sometimes a serious pest in seed fields.

CLOVER SICKNESS AND CLOVER FAILURE.

Some confusion exists regarding the nature of clover sickness, a term which appears to have been applied to a great many different causes of clover failure. In Europe this term is used to designate the condition of the land when it fails to grow continuous crops of clover, but which will again grow successful crops after an interval of five to eight years. The clover sickness of Europe is caused by the stem rot or by a minute eelworm, or nematode. Both of these organisms occur in the United States and have caused considerable damage locally. The too frequent failure to get and hold a stand of clover in America is not true clover sickness, however, but is due to several causes. Perhaps the chief of these is lack of lime or of phosphorus in the soil. Another is loss of organic matter by reason of unwise methods of farming. Use of imported seed and in some sections diseases such as those mentioned on page 28 play a part, but there are no data to show how great is the responsibility of any one of these factors.

A better term than clover sickness is clover failure. There is no mistake about the fact that good stands of red clover have of late years been harder to obtain than formerly. Frequent clover failures have been experienced mostly in the East, but also as far west as Iowa. Many factors have worked toward this end, but they may be placed in five groups: (1) Soil exhaustion; (2) improper methods of seeding, nurse crops, etc.; (3) unfit seed; (4) diseases; and (5) improper treatment the first autumn. Clover fails more often because soils have become poor in lime, phosphorus, potash, or organic matter than for all other reasons. The method of plat trials suggested on page 7 will enable the farmer to get a good line on what his fields need. If lime is badly needed there is no use wasting clover seed. If phosphorus is the limiting factor the addition of lime alone, even if the land is "sour," will have slight effect. Manure will do good more often than anything else, but when lime is needed the results from manure will be much greater after this need has been supplied than before. By making the soil conditions such as favor the growth of clover, failure can nearly always be turned to success.

Improper methods of seeding, etc., are frequently responsible for the failure to get even the start of a stand or for the death of the plants after grain harvest. A poor seed bed, poor seed, weeds,

[14] See Farmers' Bulletin 1161, Dodder.

careless seeding, or too heavy a nurse crop may all make for the early destruction of the small plants. The nurse or companion crop is frequently responsible for failure. If the season is dry the vigorous grain will take the moisture and leave the clover seedlings to dry up, or the tender plants can not endure the sudden exposure to a hot sun. Where the soil is rather hard it will help to top-dress the wheat with manure or to even scatter straw on the wheatland immediately after seeding to wheat.[15] (Fig. 21.) This will mulch the soil and help keep it cool and moist. The use of improper seed has already been referred to (p. 4). Of course, if dead seed is used there will be no stand, but foreign seed not suited to the

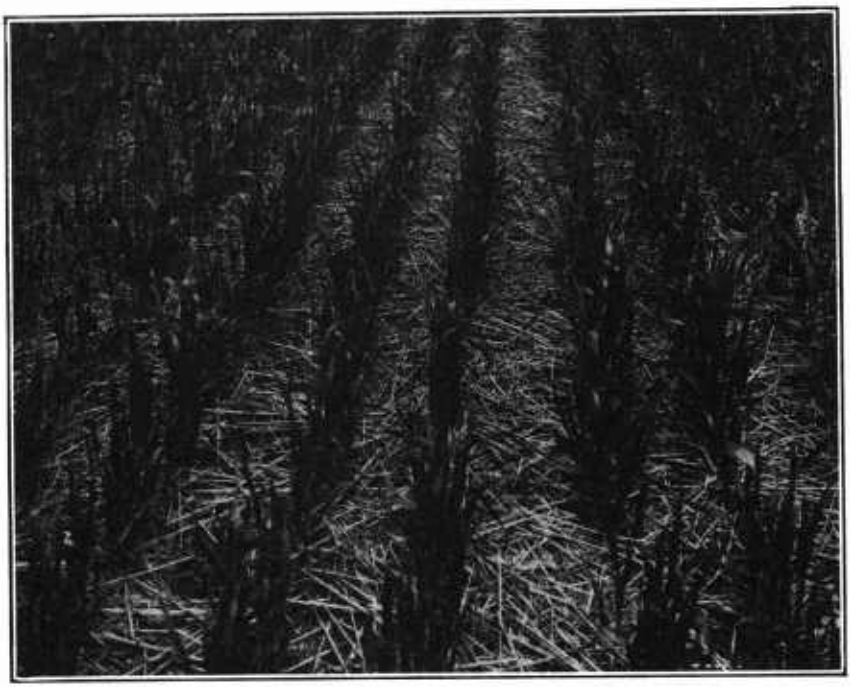


FIG. 21.—View of a wheat field on which straw has been scattered in preparation for clover seeding. The straw is put on soon after the wheat is sown, and the clover is seeded the next spring.

section where it is to be seeded may give a good stand in the fall of the seeding year, and that stand may be gone by May of the following year. It seems probable that 10 per cent of the failures of clover from Ohio eastward may be caused by the use of such seed.

Diseases except in certain localities play a minor part in extreme failure. The total yield of hay may be cut down by the various insect or fungous troubles already mentioned, but the complete destruction of the stand before a crop has been harvested is not common. Even in Idaho, where the nematode, one of the causes of clover sickness in England, is sometimes serious, the crop is seldom

[15] For an extended account of this method, see The Management of Clover in Corn-Belt Rotations, by J. A. Drake. Ohio Agr. Exp. Sta. Cir. 111, 19 p., 4 fig. 1911.

destroyed outright or even materially hurt before June of the second year.

Where red clover can not be grown without the addition of lime or other soil amendments and where the application of these is for any reason impracticable, alsike clover should first be substituted for red clover, or it may be possible to grow mammoth clover for soil improvement after common red clover will no longer thrive, and by turning under the mammoth clover the soil may be restored to a condition in which it will produce a stand of red clover.

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October 8, 1923.

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